EVALUATION OF EL DORADO PEAR FOR NORTHEAST GROWERS AND MARKETS

Optical Measurements to Determine Harvest Maturity, Ripening Changes, and Eating Quality of Pears

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ABSTRACT

Our research studies on pear storage and consumer panels indicate that the El Dorado cultivar has possibilities for eastern growers and markets. It is resistant to pear blight, a disease that limits production of most cultivars in the East, and it has a desirable shape, size, and appearance. It also has a long storage life, with very little decay or breakdown when stored at 0° to 20° C.

The eating quality of the El Dorado was considered good by 71 percent of the consumers tested; 6 percent did not like it. Only 45 percent of the consumers recognized pear cultivars sold in the market; 11 percent were familiar with the Bosc and 17 percent with the Anjou. These two cultivars would be competing with the El Dorado. Both are grown in the West and require expensive shipping for eastern markets.

A new optical measurement was used to determine harvest maturity, monitor storage ripening behavior, and establish the best ripeness for eating. A more detailed description of the optical measurement technique with pears is cited.

KEYWORDS: Consumer panels, El Dorado pear, harvest and storage maturity, optical measurements, pear marketing potential, pear quality.

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Optical Measurements to Determine Harvest Maturity, Ripening Changes, and Eating Quality of Pears

By John T. Worthington, Tom van der Zwet, Harry L. Keil, and Barbara Aulenbach 1/

Fresh pears for today's markets are grown primarily in California, Oregon, and Washington. The most important commercial cultivars are Bartlett, Anjou, Bosc, and Comice. They can be grown in these States without severe production losses from fire blight. None of these cultivars can be grown in the central and eastern United States without possible losses from this disease.

Fire blight is the most serious disease of pears in the United States. It is caused by the bacterium Erwinia amylovora, which overwinters in cankers on the limbs and trunks of pear trees. In the spring when growth begins, drops of yellow ooze containing bacteria appear on the surface of cankers. The bacteria are spread by wind, rain, and insects. The disease often starts in the blossoms and spreads down into the twigs, limbs, and trunk. By late summer the tree looks as if it has been scorched by fire.

Of 20 pear cultivars evaluated for resistance to fire blight at Beltsville, Md., from 1968 through 1973 during several epiphytotic fire blight seasons, the El Dorado was rated resistant (van der Zwet et al., 17). 2/

This cultivar originated as a chance seedling found between an orchard of Winter Nelis and Bartlett cultivars. It is similar to Bartlett in shape, but it has a longer harvest period and a storage life of 6 or more months at 0° C.

1/ John T. Worthington (retired), research horticulturist, Horticultural Crops Quality Laboratory, Tom van der Zwet, research plant pathologist, Fruit Laboratory, Harry L. Keil (deceased), research plant pathologist, Fruit Laboratory, and Barbara Aulenbach, food technologist, Horticultural Crops Quality Laboratory, Beltsville Agricultural Research Center, Beltsville, Md. 20705. T. van der Zwet is now at the Appalachian Fruit Research Station, Kearneysville, W. Va. 25430.

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2/ Underlined numbers in parentheses refer to Literature Cited at the end of this report.

With increased cost of energy, the costs of storage and long-distance transport would indicate that eastern growers might be more competitive if a cultivar could be found that could be grown in the East. A 5-year evaluation of the El Dorado cultivar as to its storage and quality attributes has suggested that it could have some production possibilities for growers in the Northeastern United States. However, its production and cultural requirements need to be studied further before large-scale plantings could be suggested for this region.

This report presents the results of a 5-year study on quality evaluation of this fruit, both from the viewpoint of the laboratory and the consumer. An optical measurement technique to assess maturity and ripening changes in conjunction with dessert quality and consumer preferences for pear is described.

REVIEW OF LITERATURE

Magness et al. (9) and Haller (7) used the pressure tester to assess harvest maturity in pears. They also used ground color as an index for maturity. Mellenthin (10) used preharvest climatic factors to determine harvest date of pears. Since the mid-1950's, Norris (11), Birth and Norris (2), Butler (6), and Birth 3/ (1) not only developed the theoretical base for optical measurements of fruits and vegetables but also designed and constructed workable experimental instruments to transmit the measurements. Bittner and Norris (4) found that a reflectance measurement from the external surface of pears correlated with harvest date. Brown et al. (5) reported that reflectance measurements could detect apple bruising. Birth and Olsen (3) could detect water core by light-transmittance measurement.

The development of a light-transmittance technique using the Difference in Optical Density (DOD) for pears was based on Worthington's previous experience with this technique for classifying tomato maturity (13, 14). This technique for measuring pears has been briefly summarized by Worthington et al. (15). They used a single-beam multiwavelength spectrophotometer for the measurement (2). We measured the physical changes associated with the water state in pears during maturity and ripening, when the internal optical density decreases. As the DOD changes, the bound water becomes free in the fruit tissues and thus alters the light-scattering properties that affect the optical density. In pears free of scald, the DOD detects internal breakdown prior to any visible external symptoms (Worthington et al., 16; Wang and Worthington, 12).

MATERIALS AND METHODS

We used the light-transmittance technique to assess the maturity at harvest of the El Dorado pear grown at Beltsville, Md. Commercially grown

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3/ Birth, G. S. Spectrophotometry of biological materials. 163 pp. 1971. [Ph. D. dissertation. Copy on file Purdue Univ., West Lafayette, Ind.]

western Anjou and Bosc pears were included in the study as controls for comparison with the El Dorado, as these two cultivars would be competing with this cultivar on eastern markets.

A schematic of the light-transmittance instrument and positioning of the fruit is shown in figure 1. The optical density measurement of the intact fruit is made through the pear, and the difference between the optical density or DOD of 690 and 740 nm is determined. A model D25 Hunterlab Color Difference Meter (Hunter, 8) was used to measure the external color of the pears based on reflectance. The a_L value is an expression of the greenness to redness. The more negative the a_L, the greener the fruit. As the fruit ripens, the external color changes from green to yellow and the a_L value becomes more positive.

Harvest Maturity Tests

El Dorado fruits were harvested from 15 trees at random at 10 weekly intervals from August 6 through October 8. These trees were 15 years old. Normal spray schedules were followed to control disease and insects. Fifty fruits of similar size were harvested from these trees at each harvest date. Each fruit was sized (diameter side to side) and skin color was measured by reflectance and expressed as a_L. DOD was measured on each fruit at each harvest. All data taken were specific to the individual fruit.

Ripening Changes at Various Storage Temperatures Expressed in DOD Values

From these El Dorado trees, 5 lots of 20 fruits each were selected from approximately 1,000 fruits harvested on September 15. The selection was

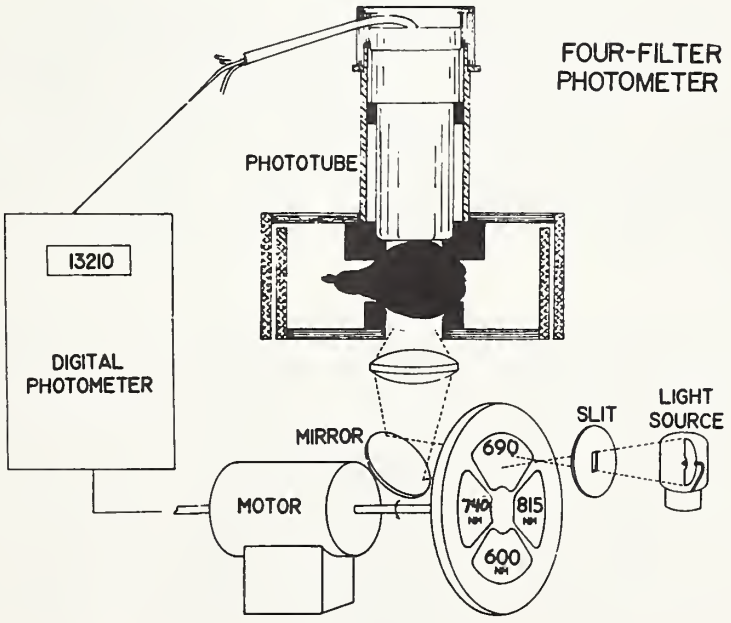

Figure 1.--Schematic of four-filter photometer.

based on size and DOD values. The DOD was 0.775 ± 0.025 for all 100 fruits used. Data were maintained throughout the tests on individual fruits. Each lot of 20 fruits was placed in the following storage regimes: 0°, 5°, 10°, 15°, and 20° C. At 10- to 20-day intervals, the fruits were removed from storage only long enough to measure and record the DOD of each fruit. This was continued until the fruits reached a DOD of 0.500 ± 0.025 or below except the 0° lot, which had not gone below 0.700 after 100 days' storage.

The Anjou pears (control) were obtained from a commercial orchard in Medford, Oreg. They were harvested on September 24, held at 0° C until October 17, and air shipped to Baltimore, Md. At Beltsville, they were placed at 0° on October 18. Five hundred fruits were sorted out with DOD, and 5 lots of 20 fruits each with a DOD of 0.650 ± 0.025 were used in the tests. These fruits were placed in the same storage regimes as the El Dorado and were measured every 10 to 20 days until they had reached a DOD of 0.300 or below except the 0° lot, which was still 0.400 after 100 days' storage.

Consumer Quality Evaluation Tests

In January 1978 and 1979, consumers were asked to evaluate the test cultivars. Age of the consumer ranged from 7 to 72 years. All the pears were stored at 0° C from early September or October to January. They were then ripened at 20° prior to serving.

A general questionnaire on pears was given to 202 consumers in 1978 (table 1). A question not listed in the table was as follows: On what criteria do you buy fresh pears--color, shape/size, texture, taste, only pear available, or no reason?

In 1978, the ballot consisted of the following statements: (1) I think this pear tastes--very poor, poor, fair, good, or excellent; (2) I would buy this pear--never, sometimes, or often. Each ballot was to be used by one taster for one sample. El Dorado was compared with western grown Bosc and Anjou. Each consumer received one coded slice of each cultivar and a coded ballot. Seven consumers tasted each pear. Thirty pears per cultivar were tasted and 205 consumers' opinions were balloted. (Fig. 2.) Records were maintained on individual pears. All these data were converted to numerical values and analyzed.

In 1979, the El Dorado was retested for eating quality and buying preference. The ballot had the following statements: (1) Eating quality--check one of seven blocks ranked from bad to good; (2) I would buy pears like this--never, sometimes, or frequently. The level of ripeness desired by the consumer for the El Dorado cultivar was tested. The ripeness levels were established by using DOD values of 0.500 ± 0.050 and 0.250 ± 0.050. Also the juiciness of the El Dorado pears at these two levels was judged by a similar number of consumers. They judged the pears not juicy to very juicy on a 1-to-7 scale and also indicated the desirable juiciness level of the pears they had just ranked. Seven consumers tasted each pear. Thirty-nine pears were tasted and 272 consumers participated.

Table 1.--General consumer opinion regarding preference and purchase of pears 1/

Questions	Answers (percent)			
(1) Do you buy fresh pears when available?	Yes 90		No 10	
(2) Do you buy canned pears?	Yes 70		No 30	
(3) How often do you buy fresh pears when available?	Once a week	Once a month	Once a year	
	39	53	8	
(4) How often do you buy canned pears?	Once a week	Once a month	Once a year	
	17	65	18	
(5) Which fresh pear cultivar do you prefer?	Bartlett	Bosc	Anjou	Do not recognize cultivar
	27	11	17	45

1/ Questions 1, 2, and 5 were based on 202 consumers and questions 3 and 4 on the number of consumers buying fresh or canned pears.

Figure 2.--Pear quality evaluation by consumers in a Washington, D.C., area shopping mall: A, Marking and coding test plates for fruit samples; B, preparing samples with a fruit slicer prior to presentation; C, presenting pear samples to test consumers; D, assisting with questionnaires and answering consumers' inquiries.

Harvest Maturity

The external color of El Dorado pears, as expressed by reflectance a_L values, did not change from the August 6 through August 26 harvests (table 2). A definite decrease in DOD occurred between these dates, indicating a decided internal change in the pears maturity. Pears harvested on September 2 were less green externally than those harvested on August 6, as indicated by the more positive a_L value. This change in visible green is too slight to evaluate with the unaided eye. The effect of harvest delay on fruit maturity, particularly from August 6 through September 17, was readily shown by a continual decrease in DOD. No change in optical density was found in pears harvested between September 17 and 30. However, externally the color changed and indicated a ripeness that really did not occur internally.

DOD for Monitoring Storage Changes

El Dorado pears were selected with an initial DOD of 0.775 $\pm$ 0.025. The effect of the different storage regimes is readily seen in figure 3. The DOD decreased from 0.775 to 0.450 at 20° C in 10 days, whereas it was 0.500 for pears stored at 5° after 55 days. No ill effects, such as scald, decay, or internal breakdown, occurred to these fruits during storage at any of the temperatures; they all ripened and were of good eating quality.

The Anjou pears were selected with an 0.650 $\pm$ 0.025 DOD at initial storage (fig. 3). This cultivar had a similar response in ripening to that of the El Dorado, except that it reached a much lower DOD before it was considered ripe enough to eat. These data indicate that the El Dorado pear has a similar

Table 2.--External color (a_L) and internal difference in optical density (DOD) of El Dorado pears at 10 harvest dates 1/

Harvest dates	a_L	DOD
Aug. 6	-14.0 a	0.582 a
12	-13.5 ab	0.544 b
18	-13.7 a	0.434 c
26	-13.3 abc	0.383 d
Sept. 2	-12.7 bcd	0.359 d
10	-12.5 cd	0.272 e
17	-12.2 d	0.215 fgh
24	-12.3 d	0.245 ef
30	-10.7 e	0.223 fgh
Oct. 8	-10.0 e	0.213 h

1/ Means within a column followed by the same letter are not significantly different at the 5-percent level as tested by Duncan's Multiple Range Test. Means consist of 50 fruits each.

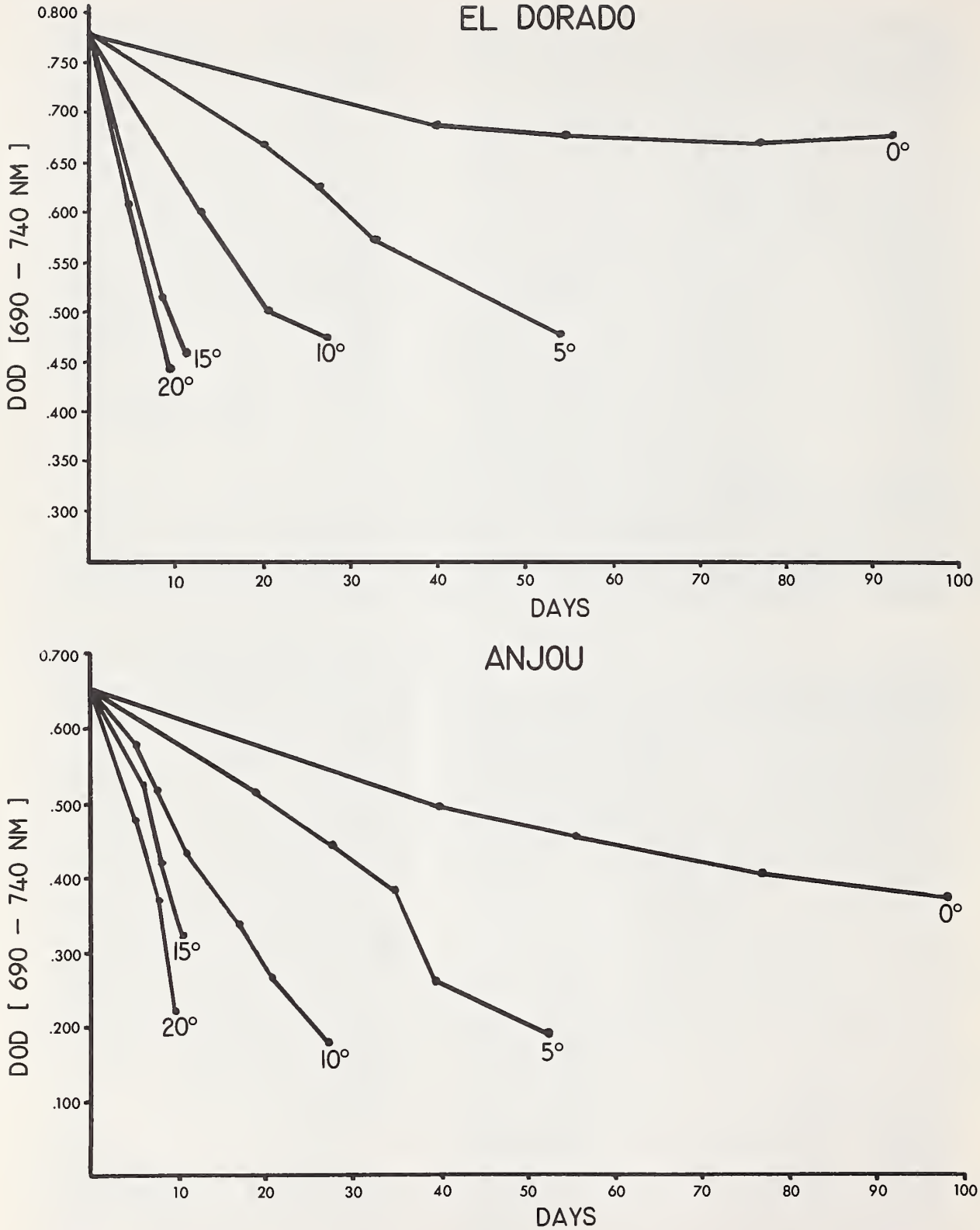

Figure 3.--Interrelationship of storage regime (°C) and ripening changes in El Dorado and Anjou pears expressed as difference in optical density at 690-740 nm.

storage duration and quality to those of the Anjou, which would be its principal competitor for sales on eastern markets. However, each cultivar will have to be evaluated and have definite DOD values specific for its proper time of harvest, storage potential, and eating quality.

Consumer Opinion of Overall Pear Quality

General opinions by consumers of pears in our 1978 sampling are found in table 1. Apparently most consumers liked fresh pears better than canned. Possibly the caloric count of the canned fruit has caused some of this effect on selection. Ninety percent of consumers indicated they would buy fresh pears. Fifty-three percent reported they would buy fresh pears once a month, whereas 39 percent indicated as often as once a week.

The most revealing finding in this survey was that 45 percent of those surveyed did not recognize the three commercial cultivars, even though a great deal of promotion has been afforded pears in newspapers and stores. However, 27 percent of those that did recognize cultivars reported they preferred Bartlett. This result could be due to unfamiliarity with the other two cultivars.

In this survey, 71 percent of consumers considered taste as their principal reason for purchasing fresh pears, with only 30 percent mentioning texture, 20 percent color, and 12 percent shape or size.

Response of Consumers to Eating Quality of El Dorado, Bosc, and Anjou Pears

The eating quality of El Dorado and Anjou in the 1978 survey was similar, whereas that of Bosc was not as good (table 3).

The ripeness of El Dorado as defined by DOD at the time of consumption resulted in a change in eating quality scores (table 4). A decrease of only 0.250 ± 0.050 DOD at the time of eating when more ripening had occurred increased the consumers' choice by almost 20 percent as to medium and good quality pears. These fruits at both DOD levels were similar in fruit firmness as indicated by pressure test readings, with both less than 1.1 kg.

The effect of DOD levels on the degree and acceptability of juiciness of El Dorado pears by consumers is presented in table 5. They considered the 0.500 DOD pears only moderately juicy and the 0.250 DOD pears very juicy. Consumers also reported that the former fruits were only moderately acceptable, whereas the latter were very acceptable. This result indicates the need for such a method to separate degree of juiciness to obtain the best consumer-acceptable quality and to show optimum potential of the quality of any pear cultivar.

DISCUSSION

With existing technology and instrumentation, optical measurement as used in these studies should enable researchers as well as quality-control personnel in industry to more accurately evaluate pear maturity and to monitor changes

Table 3.--Consumer response to eating quality of El Dorado, Bosc, and Anjou pears, winter 1978

Cultivar	Consumer scores on eating quality 1/	
	Good-excellent	Poor-very poor
	Percent	Percent
El Dorado	63	15
Bosc	52	16
Anjou	67	10

1/ 205 consumer opinions for each cultivar; remaining percentages not shown were for fair quality pears.

Table 4.--Consumer response to eating quality of El Dorado pears as affected by ripeness, winter 1979

Ripeness 1/	Consumer scores on eating quality		
	Medium-good	Fair	Bad
	Percent	Percent	Percent
Less ripe (0.500 ± 0.050 DOD)	52	29	19
More ripe (0.250 ± 0.050 DOD)	71	23	6

1/ As expressed in DOD values at time of eating and when all pressure measurements of the Magness/Taylor test were less than 1.1 kg.

Table 5.--Degree and acceptability of juiciness of El Dorado pears at 2 optical density levels, winter 1979

DOD level	Mean scores for--	
	Degree of juiciness 1/	Acceptability level of juiciness 2/
0.500 ± 0.050	4.6	4.9
0.250 ± 0.050	5.9	5.8

1/ 1 = not juicy; 2, 3, 4 = moderately juicy; 5, 6, 7 = very juicy.

2/ 1 = not acceptable; 2, 3, 4 = moderately acceptable; 5, 6, 7 = very acceptable.

in pear quality during storage. This should also help to establish the best fruit conditions for either eating or processing. Researchers would also be aided in having an accurate, reproducible, and definable term to describe maturity and ripeness. They would be able to indicate maturity and ripening level nondestructively throughout an experimental study. Thus, they would have nonbiased, calculable numbers with which to present data. Then conclusions could be drawn as to the interrelationship of causes and effects with little experimental variance resulting from biological variance in test fruits for both maturity and ripeness not discernible with the unaided eye.

It is also conceivable with electronic and optical technology developments that an inexpensive portable spectrophotometer of high accuracy and DOD range could be developed for use by the grower, inspector, commercial fruit broker, or even the consumer in selecting quality, maturity, or ripeness in pears. Also large-scale sorters could be installed for fruit specialty packers (gift packs), where quality must be maintained consistently to protect the reputation of high-quality products.

This optical measurement is very useful in setting limits of such standards as (1) when to harvest pears for best storage or optimum eating quality or storage life, (2) what grade a pear should receive if the DOD was part of the standard for quality, and (3) how long the fruit should be stored to avoid decay and nonvisible physiological (breakdown) as well as visible disorders (scald) that make the product nonsalable. Such a measurement would also enable both research and commercial fruit growers to have a universally understandable terminology.

Production attributes of El Dorado are not well known or documented on the east coast. We do know that this variety will tolerate fire blight better than any other commercial cultivar. It appears to have sufficient yield; in fact, it may have to be thinned in some years to maintain a desirable fruit size. This variety has an 8- to 10-week harvest period, which would not concentrate harvesting operations.

Our studies show that the El Dorado pear has many desirable attributes for marketing. The shape, size, and appearance of the fruit are well accepted by consumers. It has a long storage life, which can be maintained from 0° to 20° C without decay or breakdown becoming a major factor, especially if monitored with DOD at the higher ripening temperatures. El Dorado fruit does not scuff readily as does Bartlett and has very little scald. It has a high degree of juiciness and sweetness when ripened properly. Its only competition would be Bosc, Comice, or Anjou when these pears are sold during January to March. Its promotion possibilities appear feasible, as 45 percent of the consumers surveyed in our studies did not recognize cultivars, and only 11 to 17 percent were familiar with the two major competing cultivars, i.e., Bosc and Anjou. If El Dorado were trademarked and promoted, it should be accepted, since 63 percent in our consumer survey considered it good to excellent in quality. If ripened to a proper stage for eating, 71 percent considered its eating quality in a good range, and only 6 percent did not like it.

Eastern growers would be benefited by the El Dorado, especially since energy costs for both storage and transport have increased. They would definitely have the cost advantage over competing western pear growers with their

high transport cost and loss in fruit quality because of additional handling. The El Dorado cultivar appears to have a definite place on the roadside market or for the home grower.

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SCIENCE AND EDUCATION ADMINISTRATION
NORTHEASTERN REGION
AGRICULTURAL RESEARCH CENTER WEST
BELTSVILLE, MARYLAND 20705